Pacific Northwest
SMART GRID
DEMONSTRATION PROJECT

Transactive Energy Case Study

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Pacific Northwest Demonstration Project

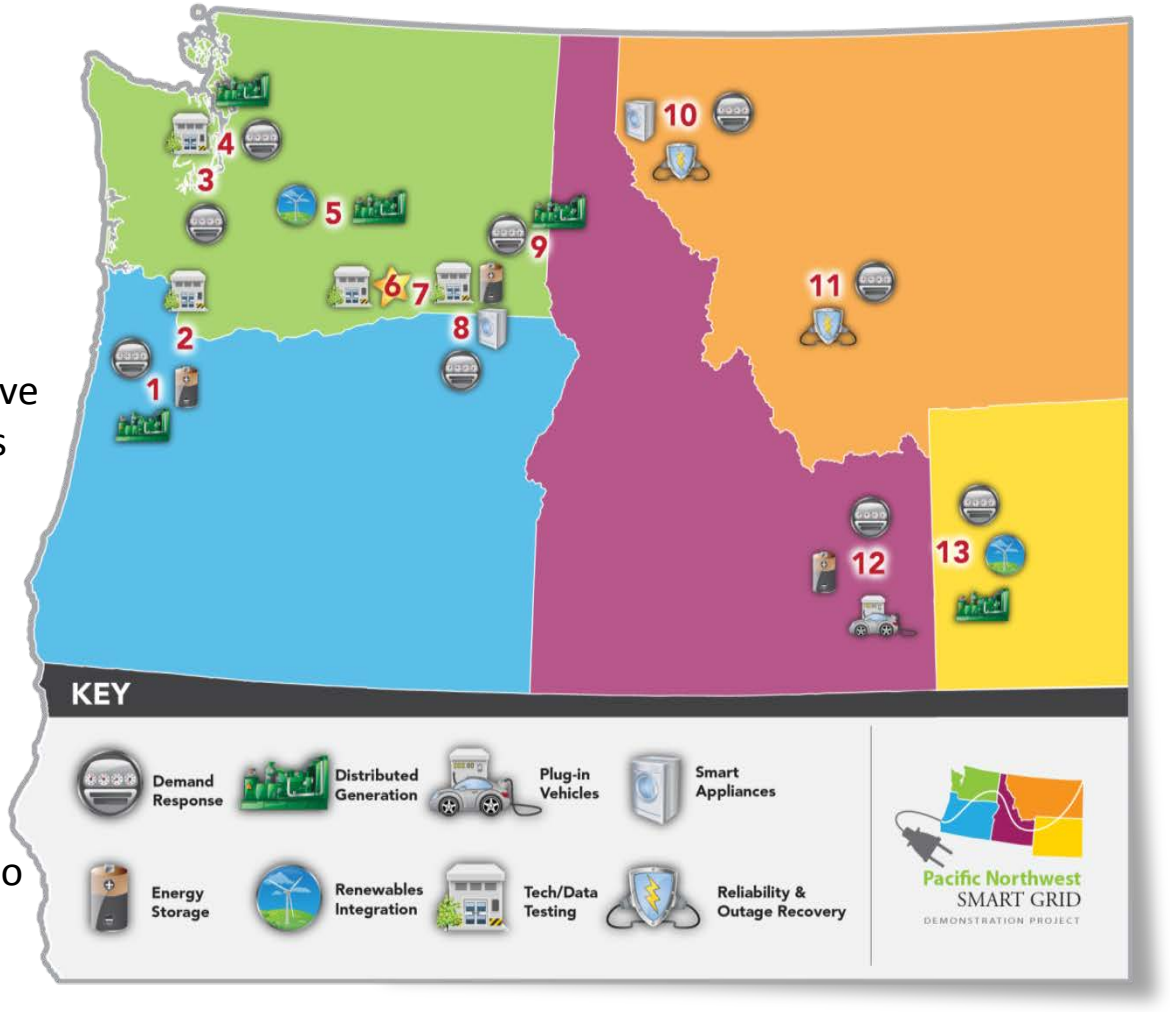
What:

- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

Why:

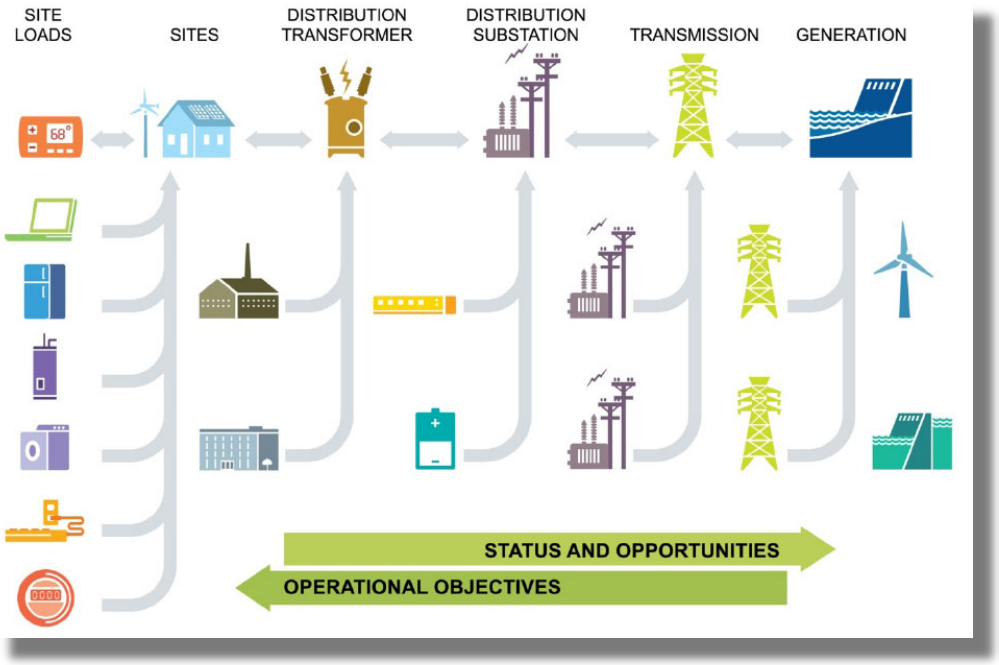
- Develop communications and control infrastructure using incentive signals to engage responsive assets
- Quantify costs and benefits
- Contribute to standards development
- Facilitate integration of wind and other renewables

Only project of its kind integrating resources across multiple utilities to achieve regional benefits.



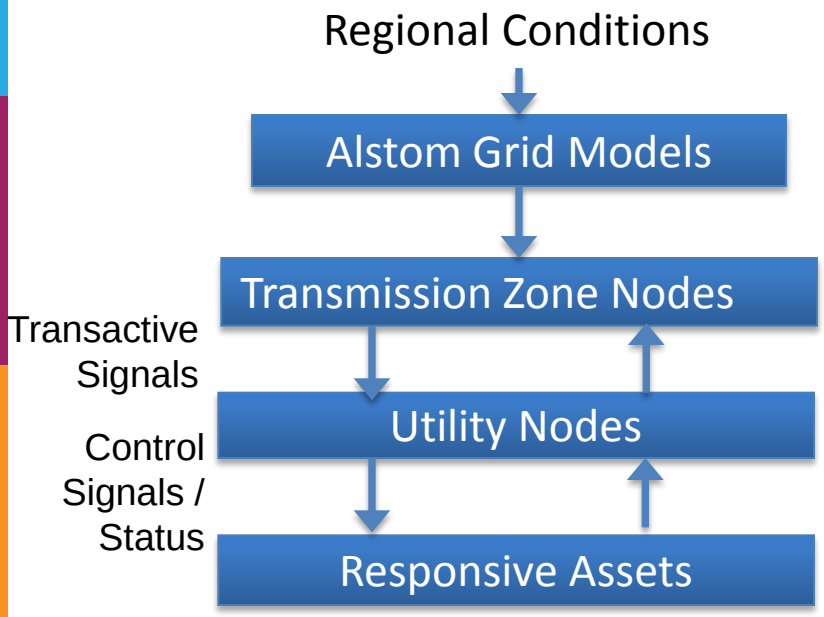
Architecture

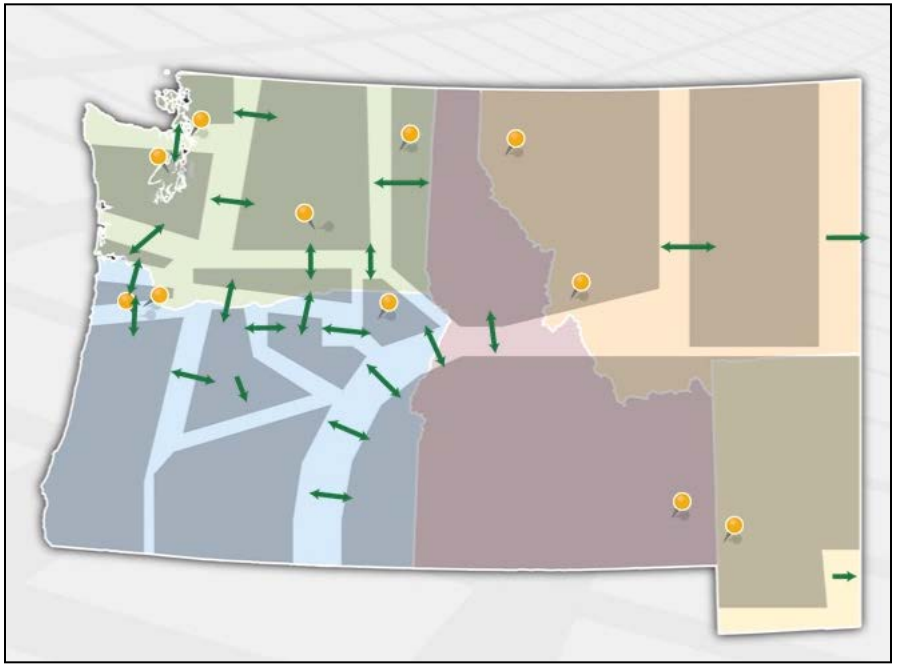
- Distributed / decentralized
- “Nodal” – follows topology of the electric power system
- Transactive control nodes
  - Distributed control points at points where flow of power may be controlled, coordinated or managed (e.g., managing constraints)
  - Meshed or hierarchical according to the electric system topology



Extent

- Designed to be used from end-to-end (bulk power to end-use)
- Multi-jurisdictional
- For demonstration being applied at interface between transmission and distribution





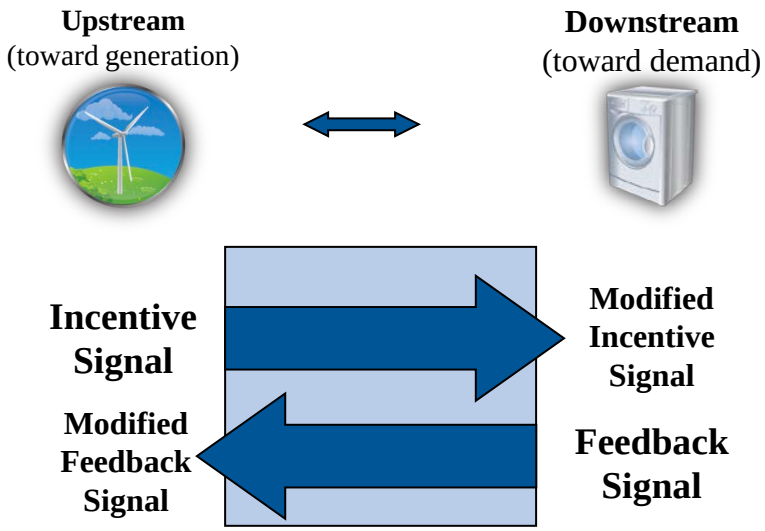
Generation inputs inform modeling of the regional system, which provides inputs into the transactive control system. The system interacts with utility assets working together to determine an action, such as charging up a battery if wind is available.

The regional model uses transmission zones as regional boundaries to create data needed for the transactive control research

Transaction

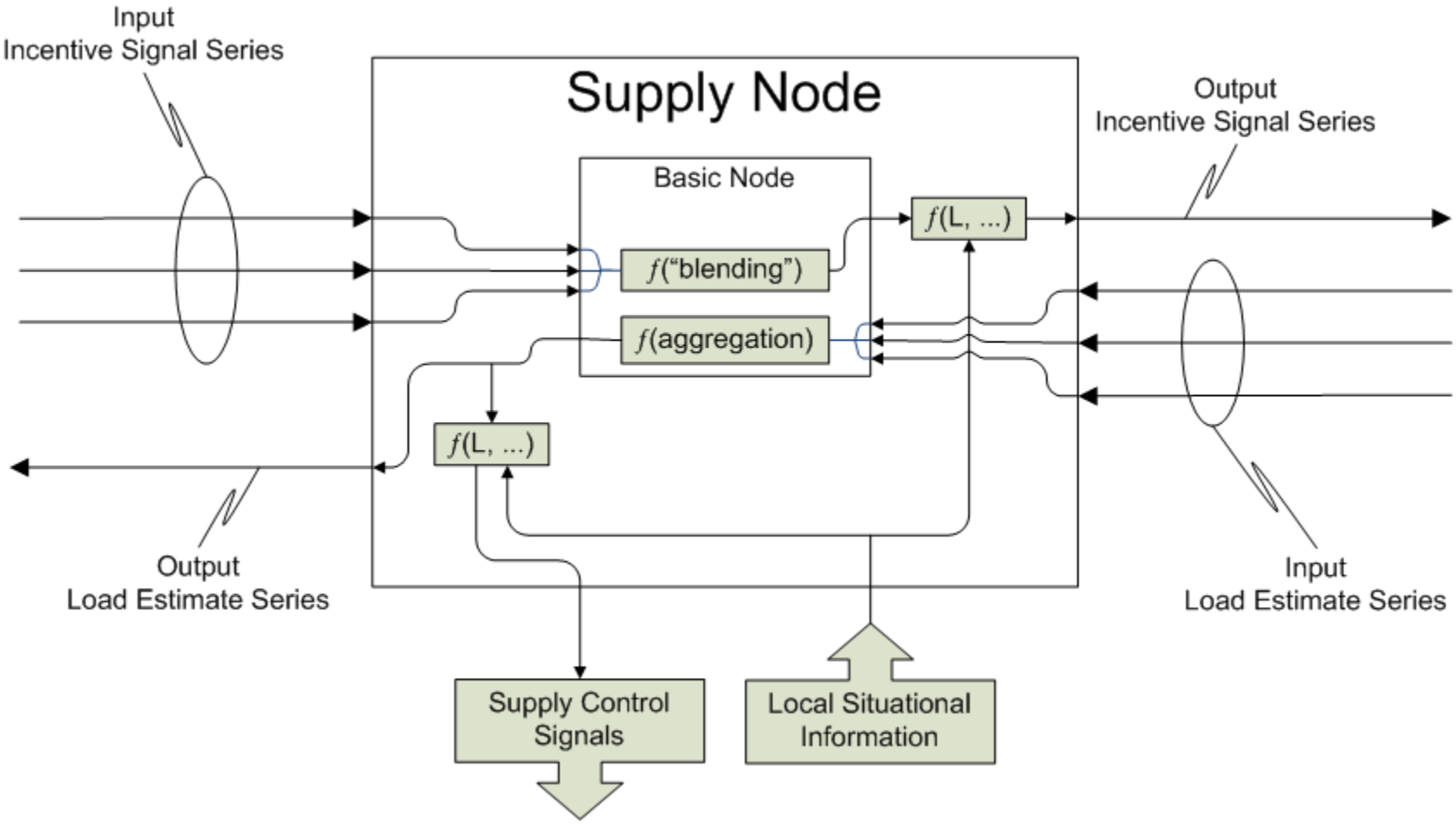
Incentive and feedback signals

- The incentive signal is a synthetic cost forecast sent to neighboring nodes
- The feedback signal is a consumption pattern forecast sent to neighboring nodes
- Iteration between neighbors results in an agreement on future cost and consumption – the “transaction”



Transacting Parties

- Transactive control nodes are the transacting parties



Temporal Variability: Demonstration IST series definition

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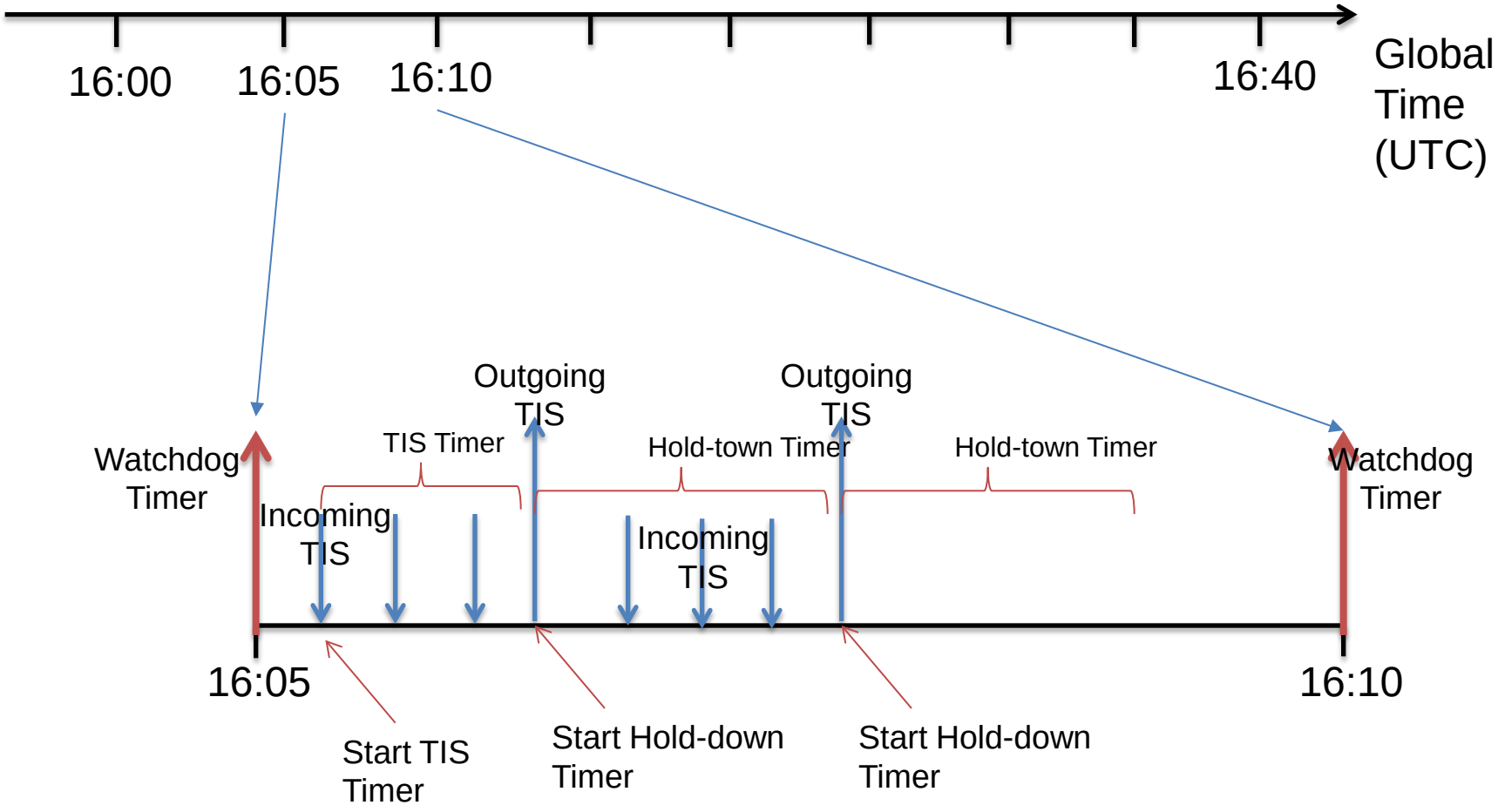
Duration	No. Intervals	Interval Start Times
5 minutes	12	IST_0, IST_0 + 0:05, …, IST_{10} + 0:05
15 minutes	20	Round(IST_{11} + 0:15)*, IST_{12} + 0:15, …, IST_{30} + 0:15
1 hour	18	Round(IST_{31} + 1:00)*, IST_{32} + 1:00, …, IST_{48} + 1:00
6 hours	4	Round(IST_{49} + 6:00)*, IST_{50} + 6:00, …, IST_{52} + 6:00
1 day	2	Round(IST_{53} + 1:00:00)*, IST_{54} + 1:00:00, IST_{55} + 1:00:00
> 3 days	56 intervals	57 interval start times (IST)

* This function "Round" indicates rounding down to the next 15-minute, 1-hour, 6-hour, or 1-day interval start time. Times are indicated as dd:hh:mm, i.e., days, hours, and minutes.

Transactive Incentive and Feedback Signal Timing



Interoperability

- Formal transactive control node object model defined
- Reference implementation of ISO/IEC 18012 used to implement transactive control toolkit
- Transactive signals standardized for all participants, including interoperability / conformance test harness, using XML schema – suitable for inclusion in one or more future standards

Value Discovery Mechanism

- A primary responsibility of a transactive control node
- Accomplished through the exchange of transactive signals (TIS and TFS) with all neighbors
- The exchange of signals stimulates a “negotiation” like process
- The negotiation ends when the change in values is lower than a threshold
- The resulting TIS and TFS represent delivered cost of energy, and average rate of energy flow between the two transactive nodes, respectively
- Value is discovered throughout the distributed system – value is dependent on location

Value Assignment

- Another primary responsibility of a transactive control node
- Accomplished via local functions matched to the assets associated with the node
  - Resource function for supply assets
  - Load functions for consumption assets
- The functions translate local information such as weather, load history, engineering parameters, and business drivers into future cost for the TIS (and future consumption plans for the TFS)

Alignment of Objectives

- Alignment of transactive control topology with power system topology supports natural alignment of objectives
- Asset owner-operators may affect the cost or consumption of power according to their operational and business objectives through the toolkit functions
- For the PNWSG Demo the bulk power system “needs” are represented in the TIS – the local utility adds their “needs”, for example avoiding demand charges, and then acts to dispatch demand or other resources according to the resulting TIS.

Stability Assurance

- The TC system implements a form of closed loop control and is expected to be stable
- Stability is not guaranteed by this form – but can be reliably achieved
- The specific analysis and/or modeling to determine the parameters that will provide this assurance has not yet been performed

Project Structure / Roles

- Battelle Memorial Institute, Pacific Northwest Division
- Bonneville Power Administration
- 11 utilities (and University of Washington) and their vendors
- 5 technology infrastructure partners